The main tendencies in elaboration of materials with high specific strength

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Two main directions in an elaboration of materials with high specific strength become apparent:

1. Elaboration of highly strengthened materials based on new developments of modern materials science and novel technologies of their production and treatment.
2. Decrease of structural weight using the materials (elements) with low density including porous materials.

Among methods, which allow obtaining the highest values of strength, different methods of producing nanostructured materials are discussed. For one-component materials two characteristic sizes of structural elements **d**, at which the change of hardening mechanisms take place, might be determined.

Using the expression ($\mathbf{\Delta\sigma = kd^{-m}}$) it was established that for grain size d>1μ **m** is equal to 1/2, and in the range 0,1μ < **d** < 1μ **m** is equal to 1. In nanostructured region a saturation of hardening or even decrease of strength may occur. The further improvement of mechanical properties may be realized using so-called “useful” impurities or alloying elements in multicomponent systems. Such impurities embedded in nanocrystalline boundaries produce “healing” of a weak points on grain boundaries. That results in an increase (many times) both hardness and strength.

For iron based materials carbon is an example of useful impurity. That is the reason why the highest values of strength were obtained with high-carbon steels.

Taken into account that 3D methods of volume hardening have a serious difficulty, especially using severe plastic deformation, the gradient-structured materials are of interest for practical applications.

The different cases of good combination of mechanical properties for porous bodies are discussed.

The main contemporary tendencies in creation of high-strength aluminum and titanium based materials are considered. The strengthening by intermetallics, borides, silicides and quasicrystals is discussed.

New family of titanium-based alloys is described in detail. It is shown that using eutectic crystallization of Ti-Si-X and Ti-B-X systems (X is Al, Zr, Nb, V, Mo, Sn etc.) allows obtaining so-called in situ composites. The best combination of heat resistance and oxidation resistance may be obtained with as-cast Ti-Si-X- alloys. Optimal combination of RT-plasticity, strength, fracture toughness and heat resistance may be achieved with these alloys as result of their thermomechanical treatment. The best values of stiffness, RT plasticity, strength can be realized with Ti-B-X or Ti-Si-B-X systems.